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III - BLENDS OF 2,3-DIMETHYLPENTANE WITH 28-R

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

MEMORANDUM REPORT

for the

Army Air Forces, Air Technical Service Command

THE EFFECT OF COMPRESSION RATIO ON KNOCK LIMITS OF HIGH-PERFORMANCE FUELS IN A CFR ENGINE

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SUMMARY

The knock-limited performance of blends of 0, 50, and 100 percent by volume of 2,3-dimethylpentane in 28-R fuel was determined with a modified F-4 engine at three sets of conditions varying from severe to mild at each of three compression ratios (6.0, 8.0, and 10.0). The knock-limited performance of 2,3-dimethylpentane is shown to have about the same sensitivity to compression ratio and inlet-air temperature as 28-R fuel. For all the conditions tested the knock-limited performance of 2,3-dimethylpentane ranges from 12 to 47 percent (average of 23 percent) higher than that of 28-R fuel.

INTRODUCTION

At the request of the Army Air Forces, Air Technical Service Command, a general program is being conducted at the Cleveland laboratory of the NACA to investigate the knock-limited performance of a selected group of aviation fuel components in relation to triptane (2,2,3-trimethylbutane). (See reference 1.) Several hydrocarbons are produced as byproducts or impurities in one of the processes of manufacturing triptane. These hydrocarbons, if left in the final product, would materially increase the production of triptane. It is the purpose of this report and of part II (reference 2) to determine the antiknock effectiveness of two of these hydrocarbons, 2,3-dimethylpentane and 2,2,3-trimethylpentane, over a wide range of engine variables.

The tests reported herein, which present the relative effects of compression ratio and inlet-air temperature on the knock-limited performance of 2,3-dimethylpentane, were conducted during November 1944.

APPARATUS AND TEST PROCEDURE

The knock-limited performance of 2,3-dimethylpentane was obtained on a modified F-4 engine with the auxiliary knock-testing equipment used for the tests reported in references 1 and 2. Data were obtained at compression ratios of 6.0, 8.0, and 10.0 for each of the following sets of operating conditions:

Condition	Inlet-air temperature (°F)	Coolant temperature (°F)	Spark advance (deg B.T.C.)
1 (severe)	225	375	45
2 (medium)	250	250	30
3 (mild)	150	250	30

Other engine conditions correspond to specification CRC-F-4-443. On the same day, blends of 0, 50, and 100 percent by volume 2,3-dimethylpentane with 28-R were tested at one of the three compression ratios and a single operating condition.

DISCUSSION OF RESULTS

The knock-limited performance data for blends of 0, 50, and 100 percent 2,3-dimethylpentane are presented in figures 1, 2, and 3 for compression ratios of 6.0, 8.0, and 10.0, respectively. Parts (a), (b), and (c) of these figures contain data at conditions 1, 2, and 3. A comparison of the data for 28-R and 2,3-dimethylpentane plus 4.53 ml TEL per gallon indicates that both fuels have similar characteristics with respect to knock-limited performance. The curves of knock-limited indicated mean effective pressure against fuel-air ratio of the two fuels were roughly parallel over the entire fuel-air-ratio range at all conditions tested.

The effect of compression ratio on the knock-limited performance of the test blends is summarized in table I. The average knock-limited performance of 2,3-dimethylpentane is about 23 percent higher than the knock-limited performance of 28-R fuel. In certain cases an increase of compression ratio from 6.0 to 10.0 resulted in a decreased antiknock effectiveness of 2,3-dimethylpentane. This decrease was not so apparent as for triptane and 2,2,3-trimethylpentane, partly because the knock-limited power attained with 2,3-dimethylpentane at low compression ratios and moderate operating conditions was much lower than that obtained with 2,2,3-trimethylpentane or triptane. Table II shows the effect of inlet-air temperature on the knock limits of blends containing 2,3-dimethylpentane and 28-R fuel at three compression ratios.

Except at a compression ratio of 10.0 and lean fuel-air mixtures, the sensitivities of 28-R fuel and 2,3-dimethylpentane to inlet-air temperature were about the same.

The data from figures 1, 2, and 3 were cross-plotted in figure 4 as compression ratio against knock-limited indicated mean effective pressure. This figure graphically summarizes the knock-limited performance data of 28-R and 2,3-dimethylpentane showing both fuels to be similarly affected by compression ratio. Similar plots presented in references 1 and 2 indicated that triptane and 2,2,3-trimethylpentane were much more sensitive to compression ratio than 28-R fuel.

A general indication of the relative merits of triptane, 2,2,3-trimethylpentane, and 2,3-dimethylpentane as functions of compression ratio is given in figure 5 at condition 2 (medium) and a fuel-air ratio of 0.065. A lack of data prevented comparisons at other fuel-air ratios. The average knock-limited indicated mean effective pressures obtained with triptane, 2,2,3-trimethylpentane, and 2,3-dimethylpentane were respectively 124, 98, and 23 percent greater than that obtained with 28-R fuel; 2,3-dimethylpentane and 28-R do have the advantage, however, of a lower sensitivity to engine severity.

SUMMARY OF RESULTS

The results of knock-limited tests of 0, 50, and 100 percent blends of 2,3-dimethylpentane and 28-R fuel in a modified F-4 engine under three operating conditions at compression ratios of 6.0, 8.0, and 10.0 are summarized as follows:

1. The knock-limited performance of 2,3-dimethylpentane has about the same sensitivity to compression ratio and inlet-air temperature as 28-R fuel.

2. For all the conditions tested the knock-limited performance of 2,3-dimethylpentane ranges from 12 to 47 percent (average of 23 percent) higher than that of 28-R fuel.

Aircraft Engine Research Laboratory,
National Advisory Committee for Aeronautics,
Cleveland, Ohio, February 10, 1945.

REFERENCES

1. Alquist, Henry E., and Tower, Leonard K.: The Effect of Compression Ratio on Knock Limits of High-Performance Fuels in a CFR Engine. I - Blends of Triptane and 28-R Fuel. NACA MR No. E4J10, 1944.

2. Alquist, Henry E., and Tower, Leonard K.: The Effect of Compression Ratio on Knock Limits of High-Performance Fuels in a CFR Engine. II - Blends of 2,2,3-Trimethylpentane with 28-R. NACA MR No. E5A10, 1945.

TABLE I - EFFECT OF COMPRESSION RATIO ON THE KNOCK LIMITS OF BLENDS CONTAINING

2,3-DIMETHYLPENTANE AND 28-R FUEL AT THREE SETS OF ENGINE CONDITIONS

[Condition 1: inlet-air temperature, 225° F; coolant temperature, 375° F; spark advance, 45° B.T.C.
Condition 2: inlet-air temperature, 250° F; coolant temperature, 250° F; spark advance, 30° B.T.C.
Condition 3: inlet-air temperature, 150° F; coolant temperature, 250° F; spark advance, 30° B.T.C.]

Percentage 2,3-dimethyl-pentane in final blend[a]	imep ratio[b]											
	F/A = 0.0625			F/A = 0.070			F/A = 0.090			F/A = 0.110		
	Condition			Condition			Condition			Condition		
	1	2	3	1	2	3	1	2	3	1	2	3
Compression ratio, 6.0												
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	1.09	1.13	1.13	1.10	1.14	1.16	1.10	1.11	1.13	1.07	1.07	1.09
100	1.21	1.29	1.29	1.27	1.26	1.30	1.20	1.20	1.22	1.17	1.20	1.13
Compression ratio, 8.0												
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	1.17	1.15	1.12	1.20	1.13	1.11	1.21	1.13	1.10	1.09	1.09	1.09
100	1.33	1.23	1.26	1.47	1.26	1.23	1.36	1.23	1.22	1.15	1.24	1.20
Compression ratio, 10.0												
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	1.00	1.04	1.13	1.00	1.02	1.12	1.00	1.11	1.10	1.05	1.07	1.11
100	1.12	1.17	1.28	1.15	1.16	1.25	1.28	1.22	1.21	1.21	1.18	1.19

[a]Lead concentration, approximately 4.53 ml TEL/gal.
[b]imep ratio = imep of blend/imep of 28-R fuel.

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TABLE II - EFFECT OF INLET-AIR TEMPERATURE ON THE KNOCK LIMITS OF BLENDS CONTAINING 2,3-DIMETHYLPENTANE AND 28-R FUEL AT THREE COMPRESSION RATIOS

[F-4 engine operating at mild and medium conditions: inlet-air temperatures, 150° F and 250° F; coolant temperature, 250° F; spark advance, 30° B.T.C.]

Percentage 2,3-dimethyl-pentane in final blend[a]	F/A = 0.0625		F/A = 0.070		F/A = 0.080		F/A = 0.090	
	imep ratio[b]	imep difference[c]	imep ratio[b]	imep difference[c]	imep ratio[b]	imep difference[c]	imep ratio[b]	imep difference[c]
Compression ratio, 6.0								
0	1.22	39	1.14	27	1.10	22	1.05	12
50	1.22	45	1.15	35	1.11	28	1.07	18
100	1.22	50	1.17	42	1.11	30	1.07	20
Compression ratio, 8.0								
0	1.13	20	1.15	24	1.11	20	1.06	12
50	1.12	21	1.13	23	1.07	15	1.03	7
100	1.18	33	1.12	24	1.10	21	1.06	13
Compression ratio, 10.0								
0	1.33	32	1.33	33	1.31	35	1.28	36
50	1.45	46	1.48	49	1.36	44	1.27	39
100	1.45	52	1.46	53	1.39	53	1.26	42

[a]Lead concentration, approximately 4.53 ml TEL/gal.
[b]imep ratio = imep at 150° F/imep at 250° F.
[c]imep difference = imep at 150° F - imep at 250° F.

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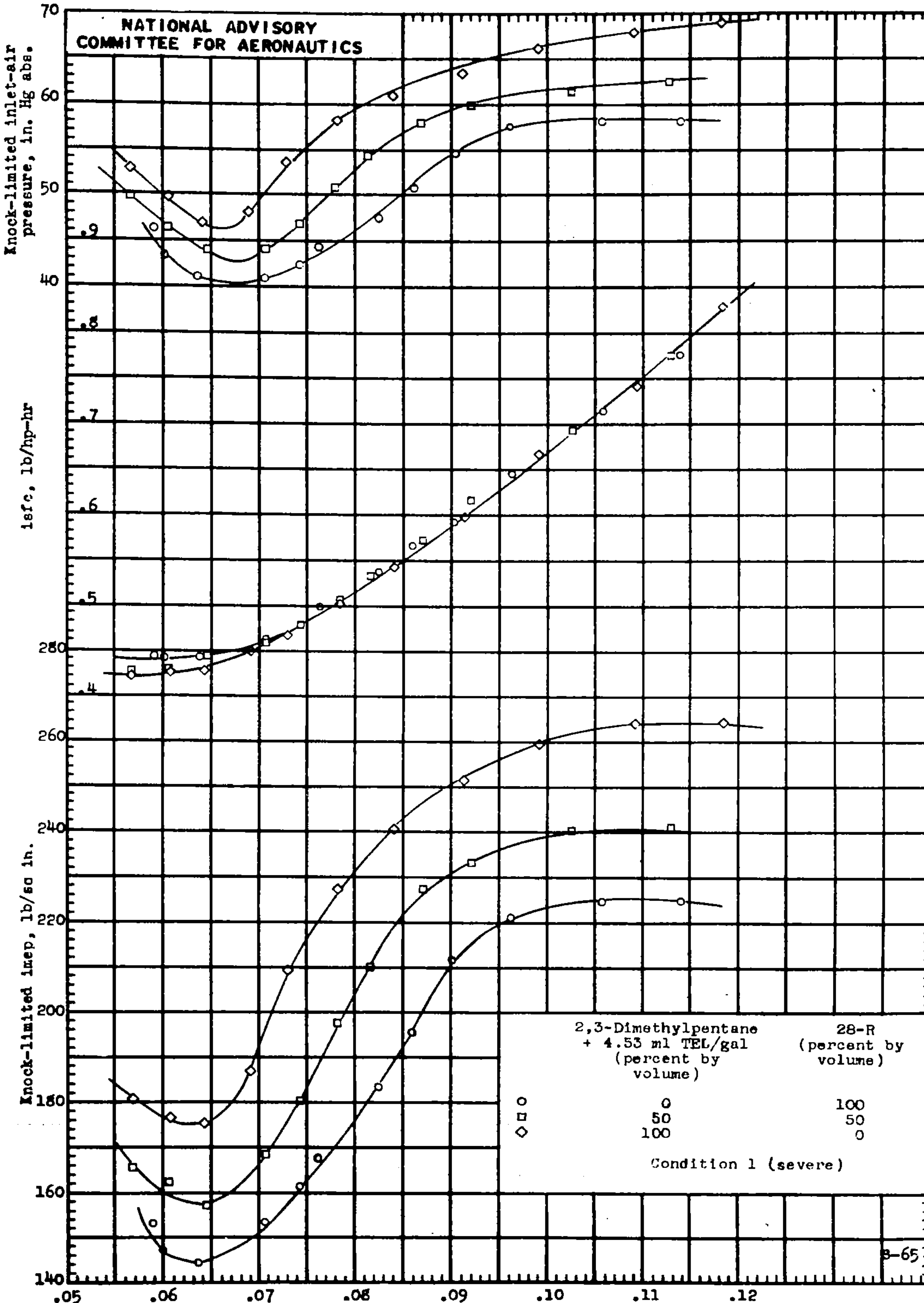
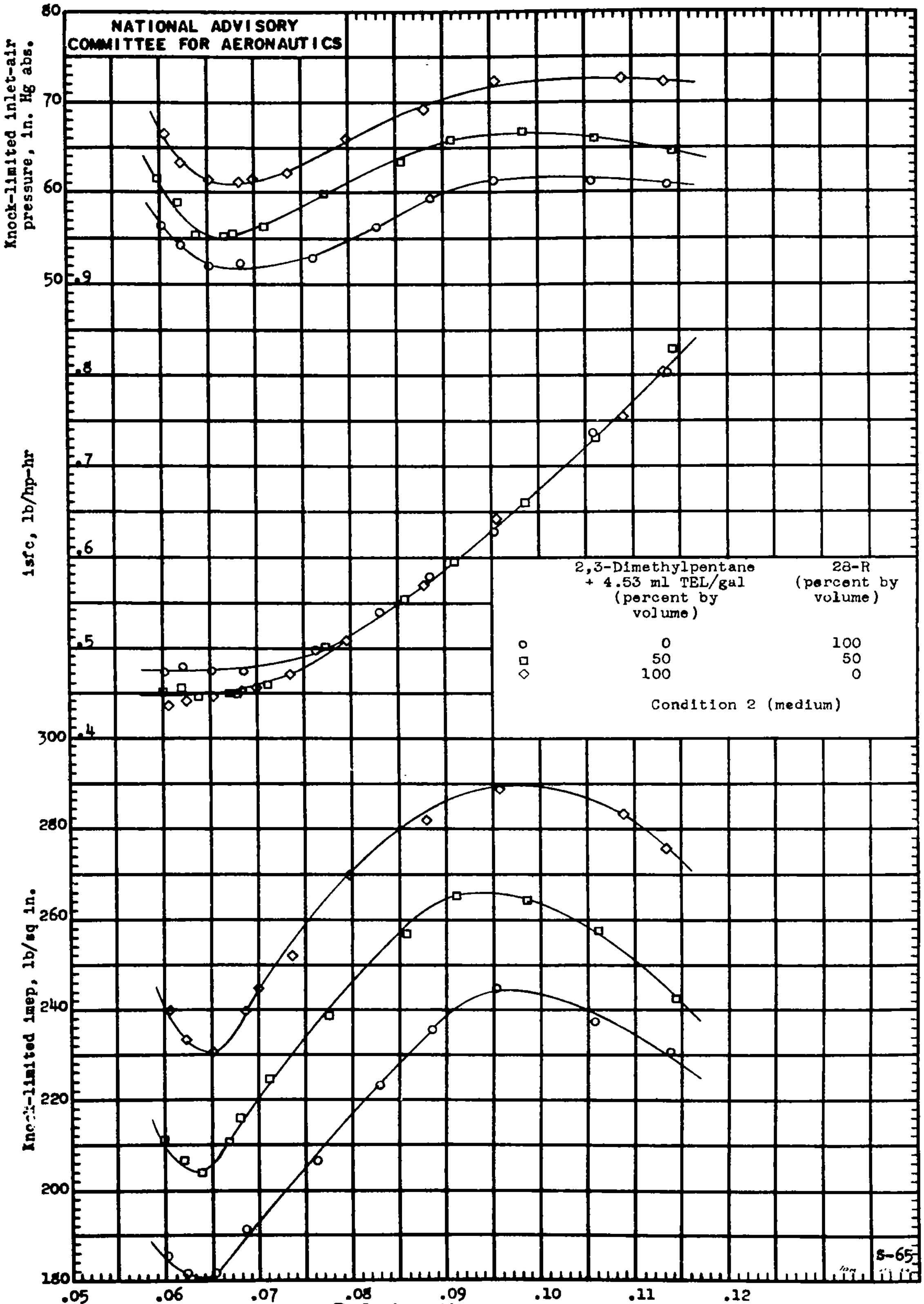
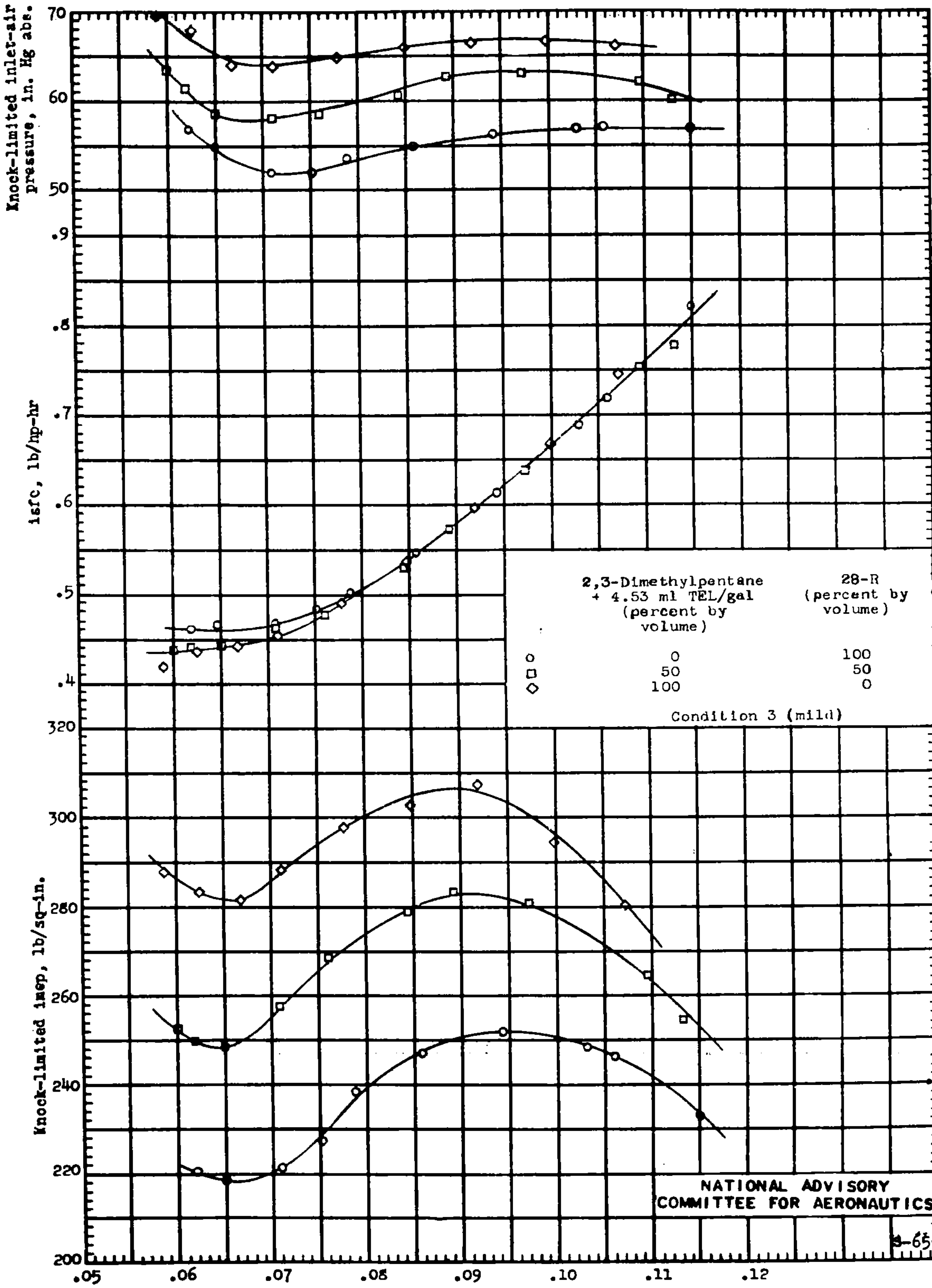


(a) Inlet-air temperature, 225° F; coolant temperature, 375° F; spark advance, 45° B.T.C.

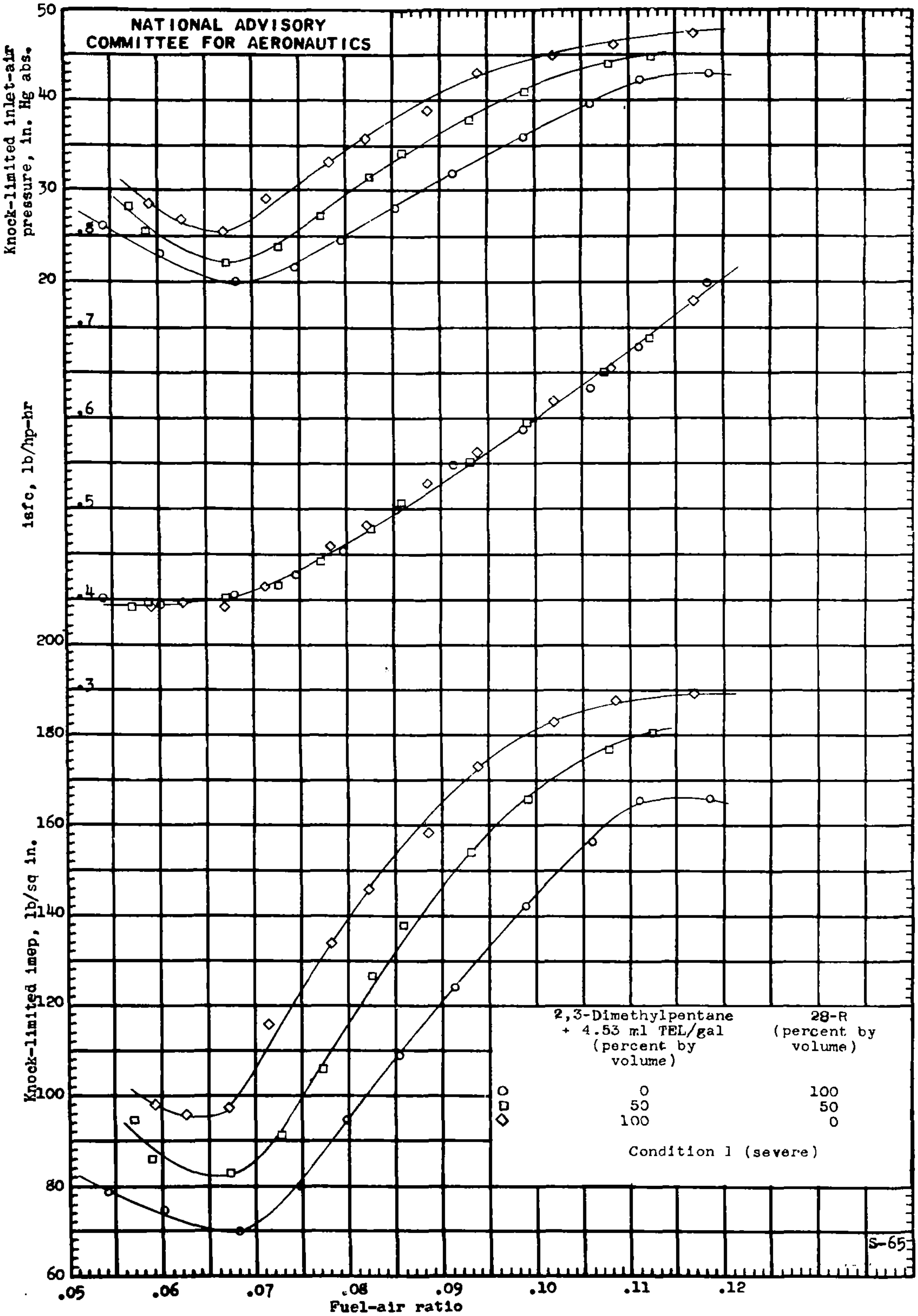
Figure 1. - Knock-limited performance of blends of 2,3-dimethylpentane and 28-R fuel in CFR engine at compression ratio of 6.0. Engine speed, 1800 rpm; oil temperature, 165° F.



(b) Inlet-air temperature, 250° F; coolant temperature, 250° F; spark advance, 30° B.T.C.
Figure 1. - Continued.

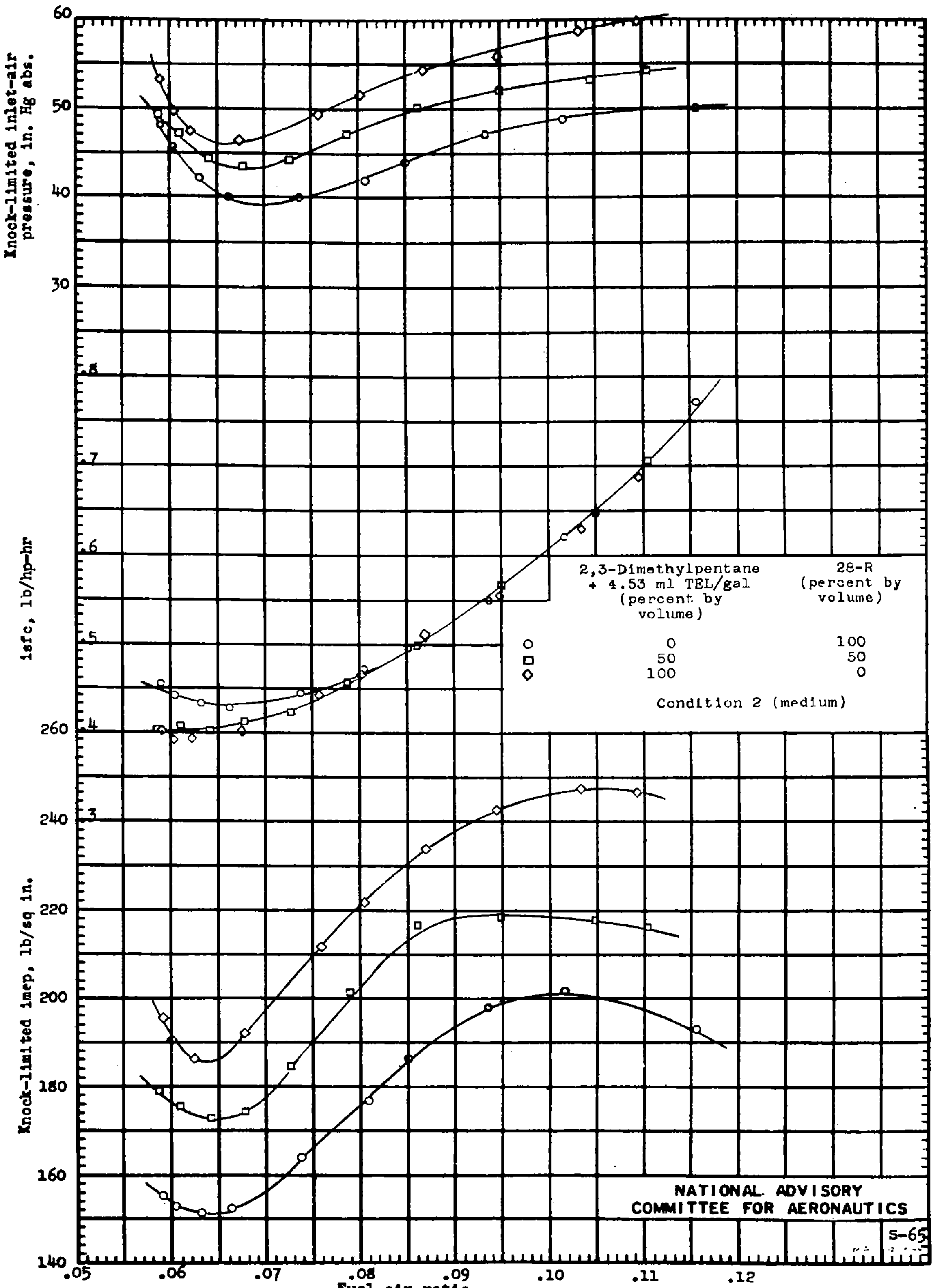


(c) Inlet-air temperature, 150° F; coolant temperature, 250° F; spark advance, 30° B.T.C.
Figure 1. - Concluded.

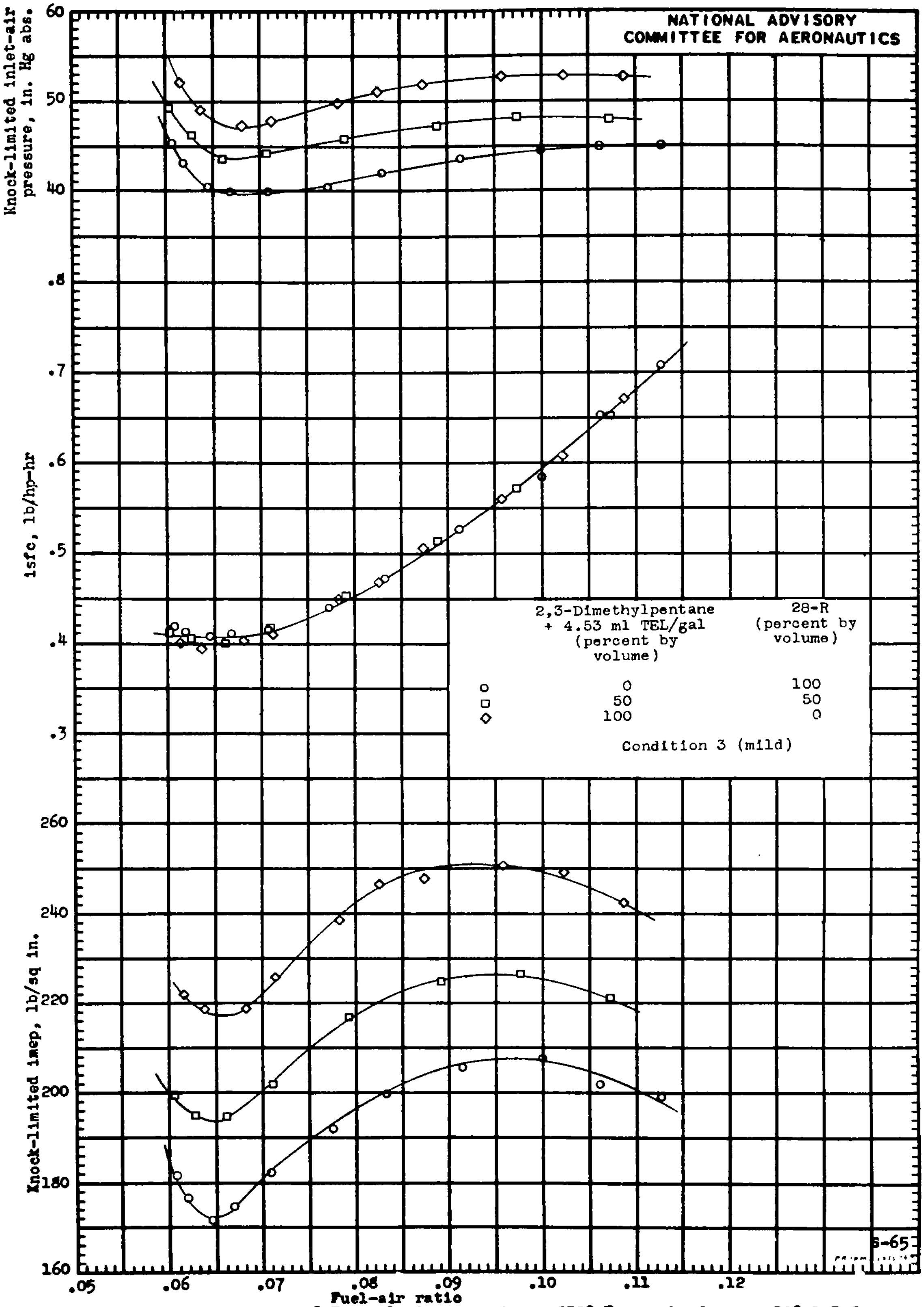


(a) Inlet-air temperature, 225° F; coolant temperature, 375° F; spark advance, 45° B.T.C.

Figure 2. - Knock-limited performance of blends of 2,3-dimethylpentane and 28-R fuel in CFR engine at compression ratio of 8.0. Engine speed, 1800 rpm; oil temperature, 165° F.

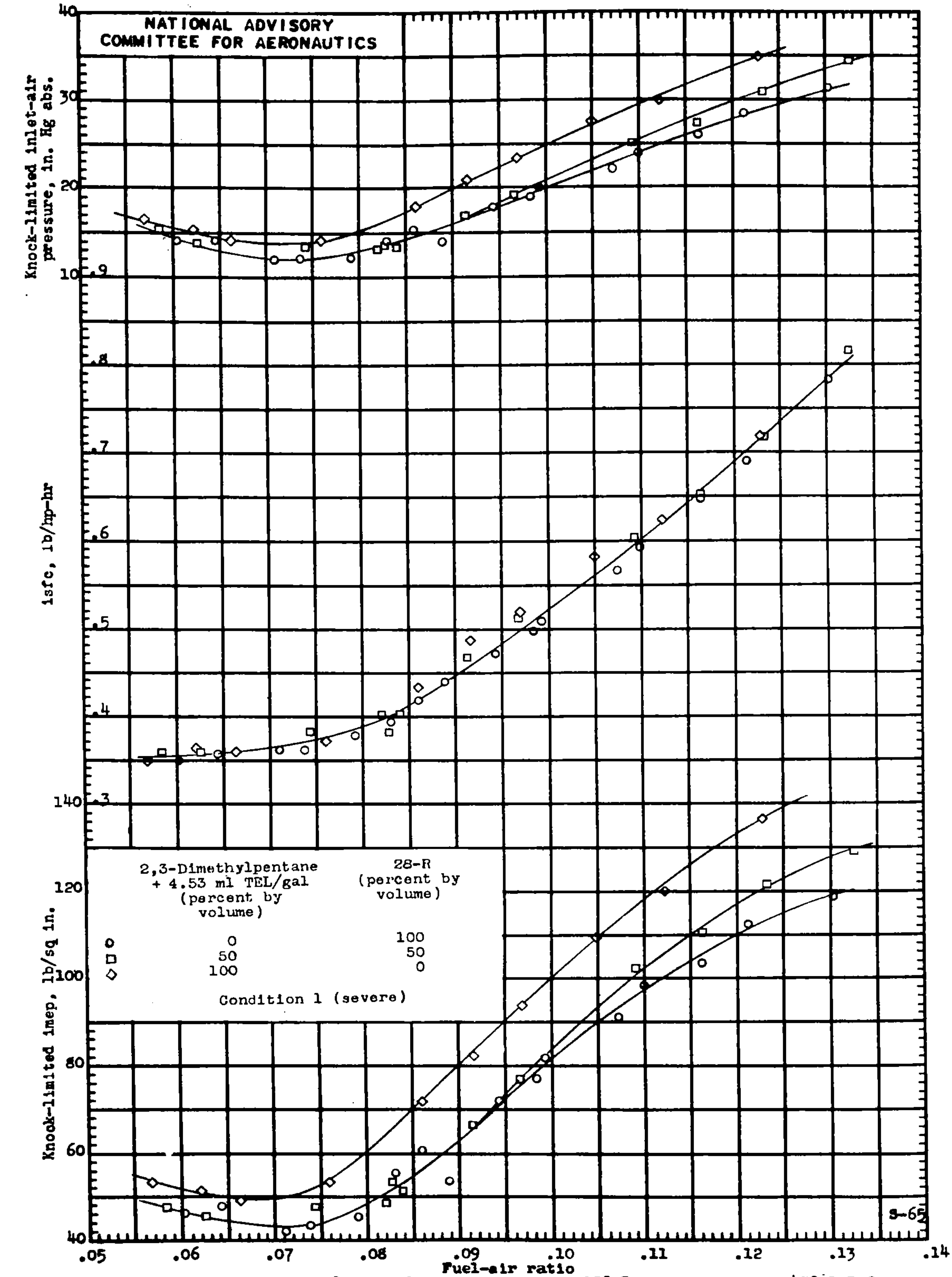


(b) Inlet-air temperature, 250° F; coolant temperature, 250° F; spark advance, 30° B.T.C.
Figure 2. - Continued.



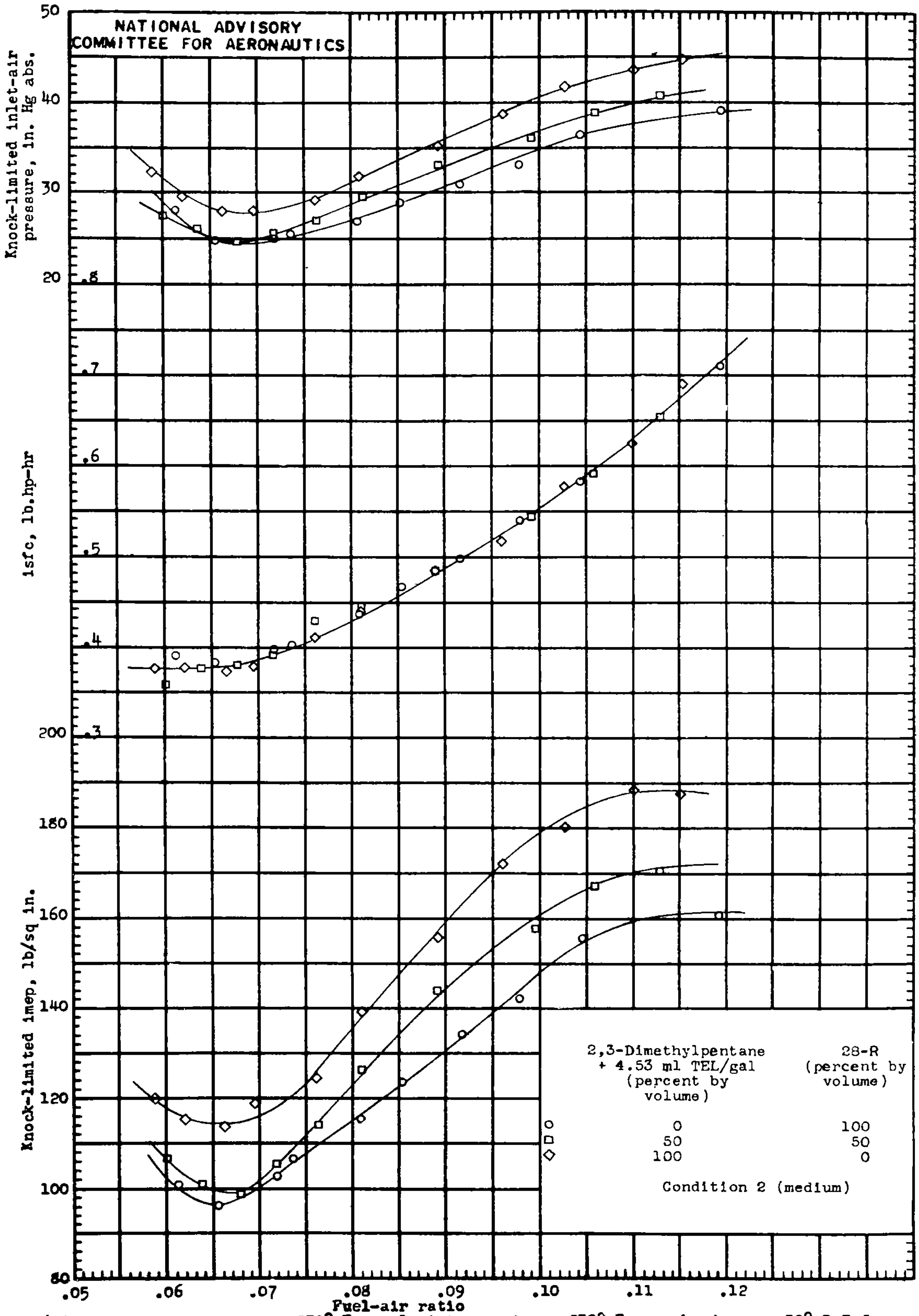
(c) Inlet-air temperature, 150° F; coolant temperature, 250° F; spark advance, 30° B.T.C.

Figure 2. - Concluded.

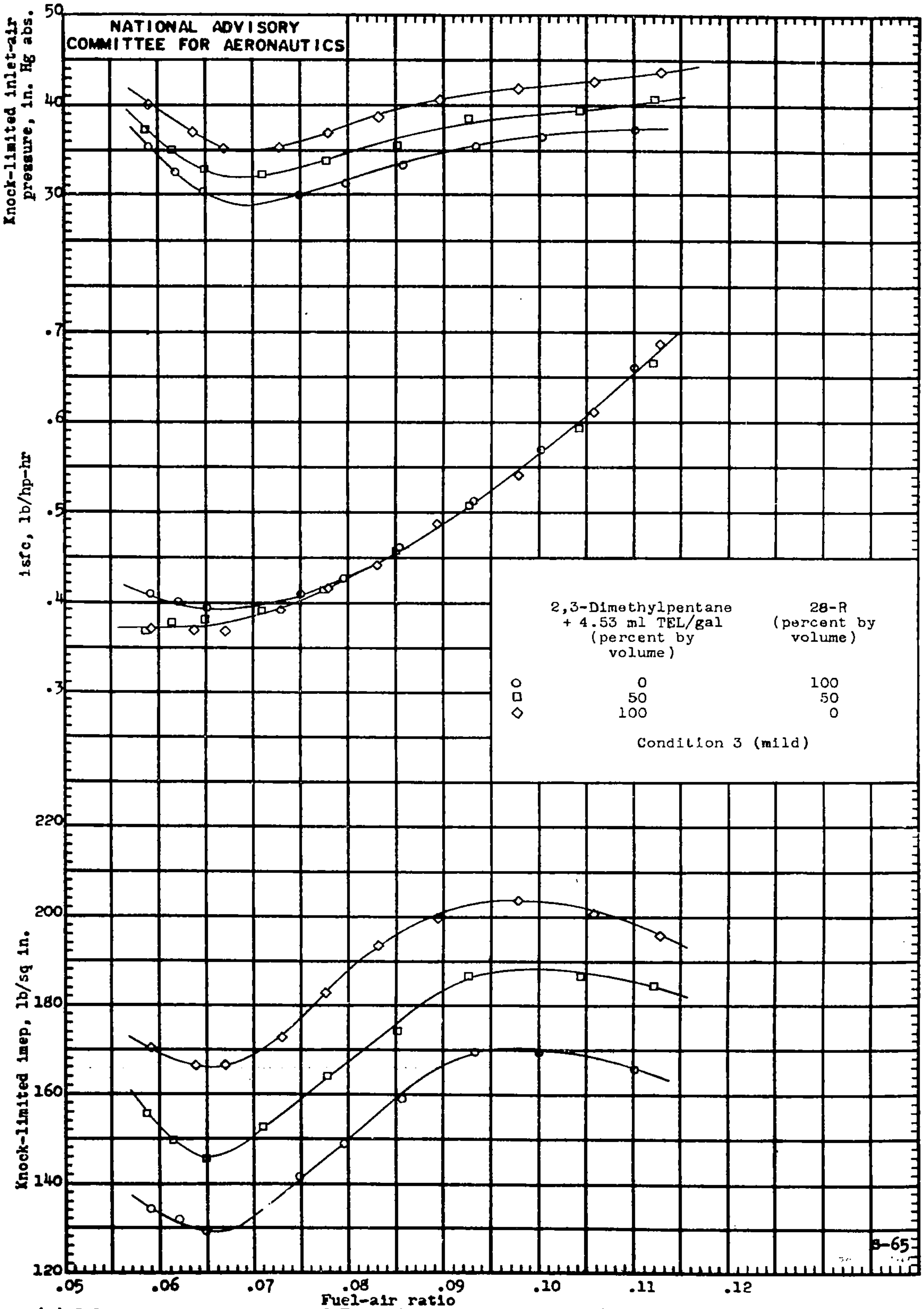


(a) Inlet-air temperature, 225° F; coolant temperature, 375° F; spark advance, 45° B.T.C.

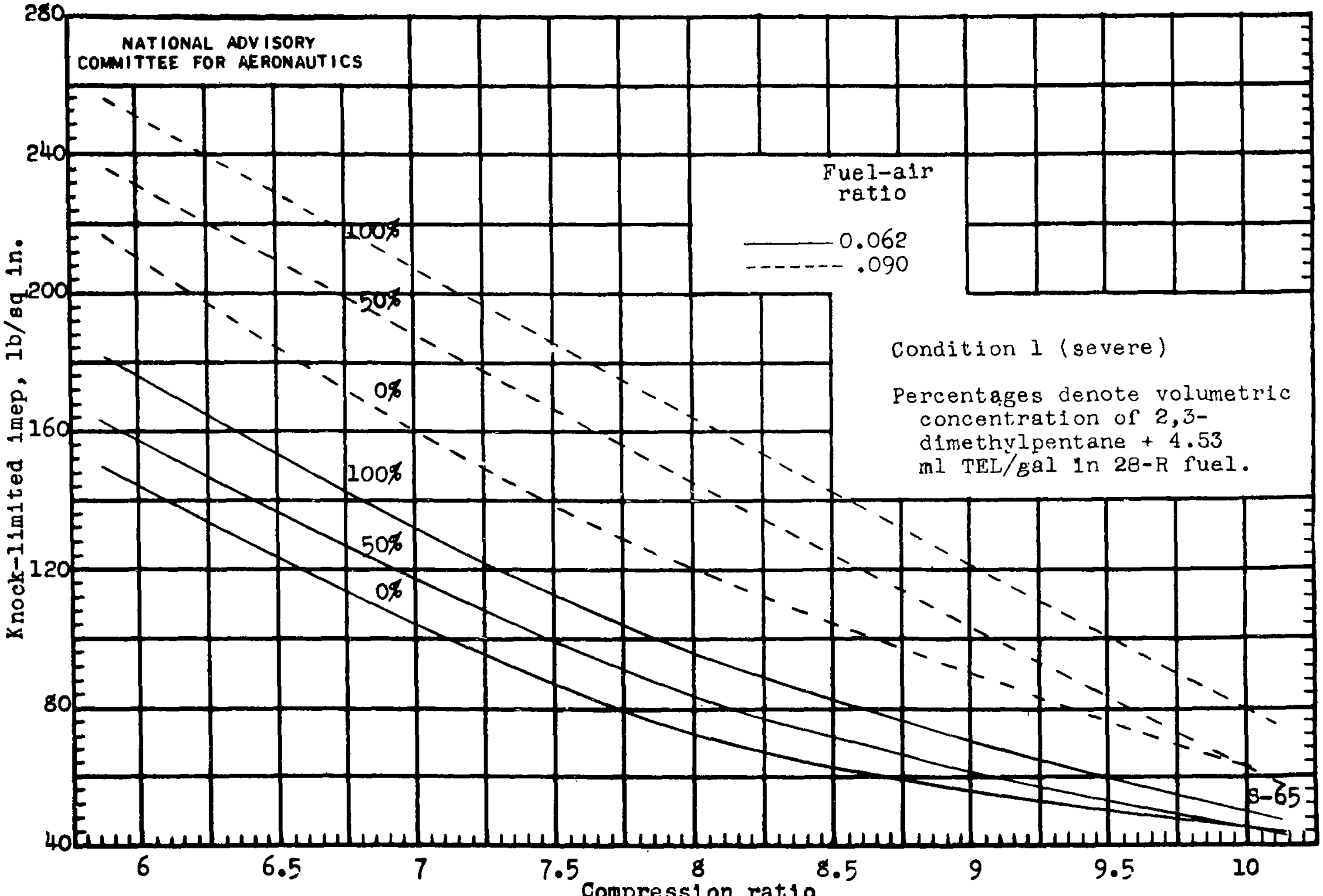
Figure 3. - Knock-limited performance of blends of 2,3-dimethylpentane and 28-R fuel in CFR engine at compression ratio of 10.0. Engine speed, 1800 rpm; oil temperature, 165° F.



(b) Inlet-air temperature, 250° F; coolant temperature, 250° F; spark advance, 30° B.T.C.
Figure 3. - Continued.

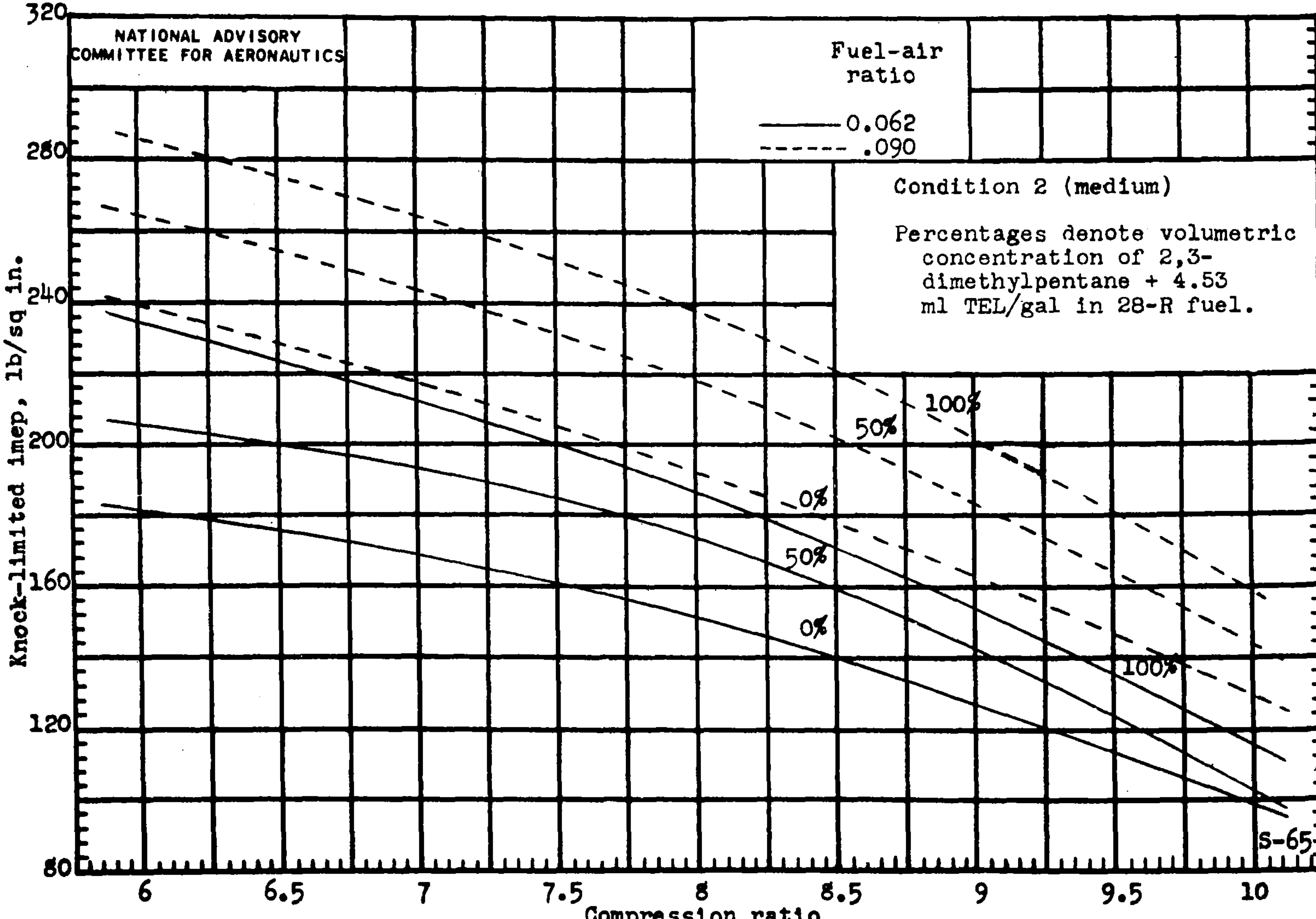


(c) Inlet-air temperature, 150° F; coolant temperature, 250° F; spark advance, 30° B.T.C.
Figure 3. - Concluded.

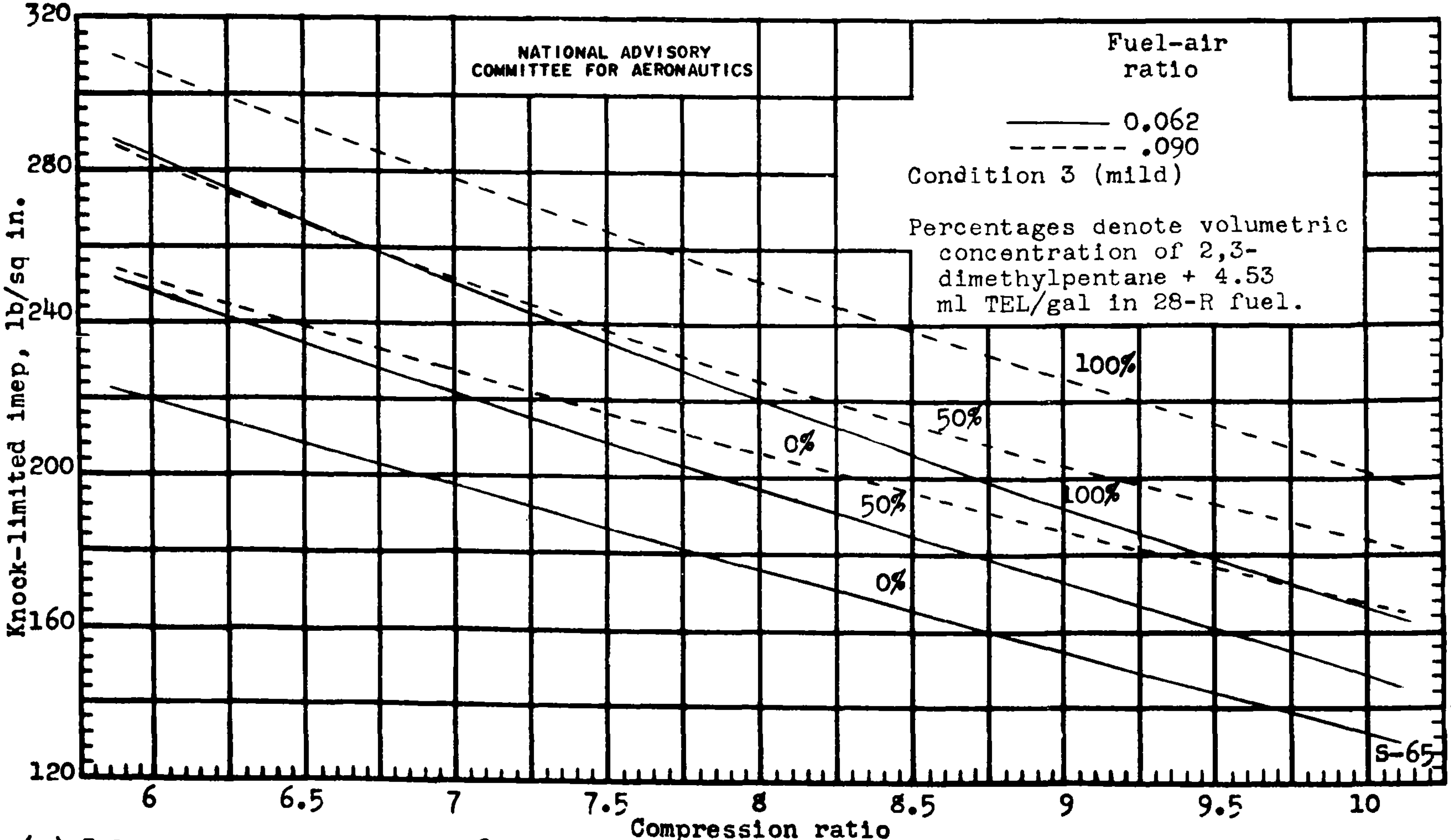


(a) Inlet-air temperature, 225° F; coolant temperature, 375° F; spark advance, 45° B.T.C.

Figure 4. - Effect of compression ratio on knock-limited performance of 0, 50, and 100 percent 2,3-dimethylpentane in 28-R fuel at fuel-air ratios of 0.062 and 0.090. Engine speed, 1800 rpm; oil temperature, 165° F.



(b) Inlet-air temperature, 250° F; coolant temperature, 250° F; spark advance, 30° B.T.C.
Figure 4. - Continued.



(c) Inlet-air temperature, 150° F; coolant temperature, 250° F; spark advance, 30° B.T.C.

Figure 4. - Concluded.

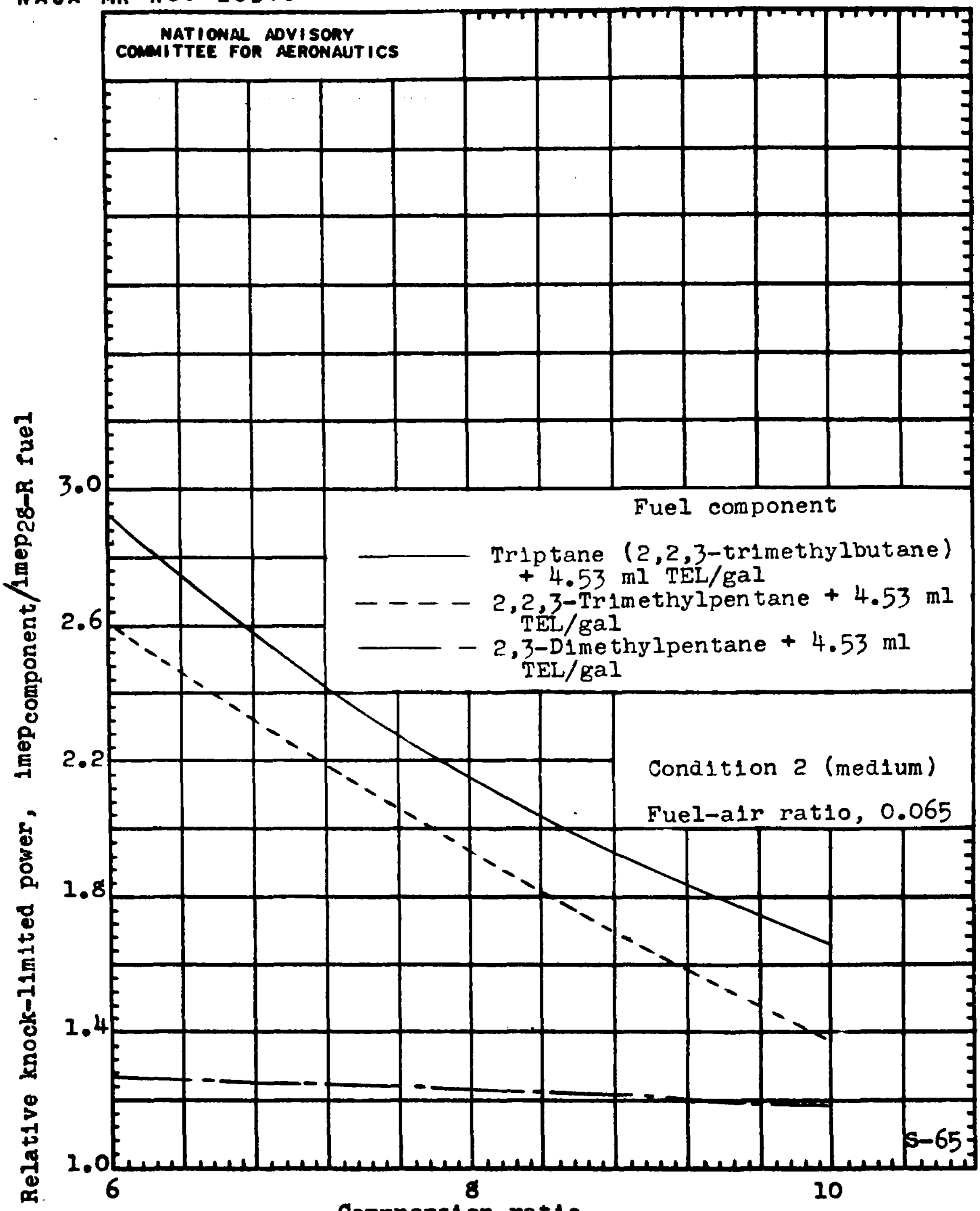


Figure 5. - A comparison of the effectiveness of triptane, 2,2,3-trimethylpentane, and 2,3-dimethylpentane relative to 28-R fuel. Inlet-air temperature, 250° F; coolant temperature, 250° F; spark advance, 30° B.T.C.; engine speed, 1800 rpm; oil temperature, 165° F. Data for triptane and 2,2,3-trimethylpentane taken from reference 1 and 2, respectively.